Self-assembled Heterostructures for Energy

Opportunity

Important elementary steps in energy-relevant processes occur on the nanoscale but require energy/electron exchange within mesoscale gradient structures. Self-assembly of nanoscale components into energy gradient architectures can result in emergent behavior at the mesoscale that guides energy electron and charge flow thus perfecting electron transfer, catalysis, energy conversion and storage.

Meso Challenge

How to control self-assembly to achieve desired morphology, band alignment and functionality.

How to create hybrid properties as a result of exchange interactions between adjacent nanomaterials. Discover/demonstrate unique functionality of these structures

How to preserve connectivity, ion/electron/thermal conductivity within the mesoscale assembly.

Approach

Discover nanoscale components with desired properties that are capable of assembling into hybrid mesoscale architectures

Control self-assembly behavior through processing conditions/surface modification etc.

Self-organization of materials into energy gradient structures

Control and visualize mesoscale behavior through in-situ characterization: correlation with microstructure

Impact

Simple approach to tailoring the electronic, mechanical and chemical properties of materials and harnessing combined functionalities at the mesoscale.

Multi-component nanoarchitectures that are built from the molecular level enabling detailed control over morphology for energy gradient optimization.

References: Darling et al. Nano Letters 11 (2011) 3707-3713; Shevchenko, E. V., Talapin, D. V. et al. Nature 2006, 439 (7072), 55-59

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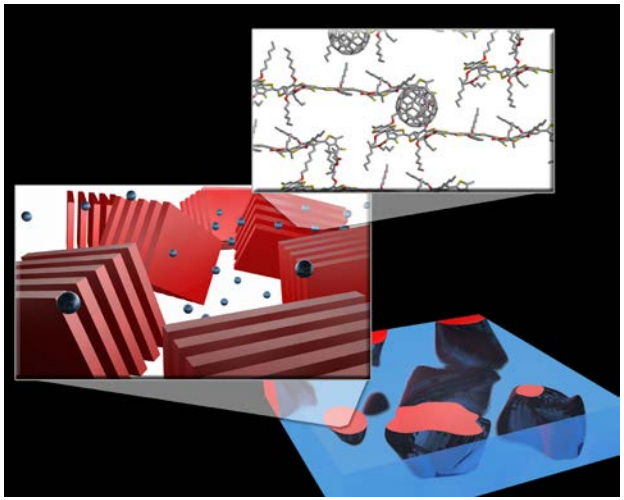
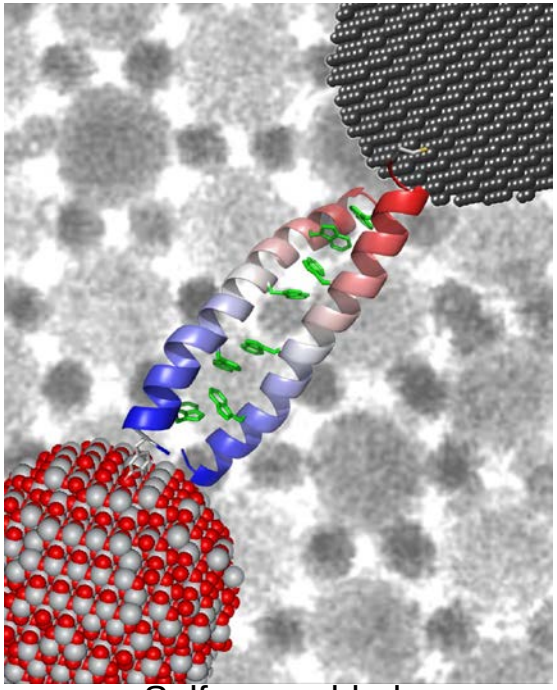
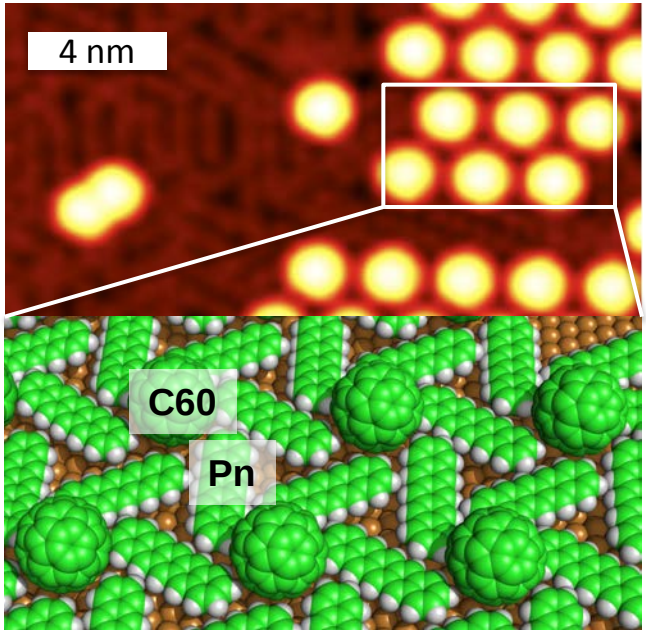


Self-assembly of organic electron–donor and –acceptor materials into hierarchical morphologies



Self-assembled semiconductor/metal hybrid for artificial photosynthesis. Biomolecule acts as linker



Single-layer heterojunction created by chiral self-assembly of C_{60} and pentacene

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